Name ____ AP Chemistry

NASA Needs Water

Introduction

The law of conservation of mass/matter states that matter cannot be created or destroyed in a chemical reaction. This law was first proposed by Antoine Lavoisier in 1789. The concept of the conservation of mass is the cornerstone on which the development of modern chemistry is based. Alchemy evolved into chemistry as scientists performed quantitative studies of chemical processes and transformations. These studies showed that chemical processes are simple reactions between invariant amounts or weighs of the elements.

Humans have long been fascinated with outer space and the possibility that life exists on other planets. Scientists have been searching for water in outer space and the possibility that life exists on other planets. Scientists have been searching for water in outer space because it is one of the most important compounds necessary to sustain life. Water is a source of both hydrogen and oxygen; hydrogen could be used to make fuel, and oxygen is needed to sustain life. Thus, sources of water in outer space would facilitate space travel to the far reaches of our galaxy.

Water has been found in outer space, on the Moon, and on Mars[1]. Images of Mars suggest that it may have been a habitable planet. The images show deep channels and canyons and perhaps even ancient shorelines, all suggestive of water being present. The polar caps of Mars are believed to contain frozen water under layers of frozen carbon dioxide. Minerals discovered Mars that contain water or require water to form include phyllosilicates[2], hydrated inorganic salts[3], and opal[4].

In today's scenario, you are a NASA employee charged with evaluating some of the hydrated inorganic salts on Earth and Mars. You must identify an unknown hydrate and evaluate its potential as a water storage system for use in outer space. Moderate heating will drive off the waters of hydration leaving the anhydrous ionic solid. Such hydrates are said to have "water of crystallization" or "water of hydrogen." The chemical formula for a hydrate is written using a "dot" between the formula for the ionic solid and the water(s). A common hydrate of copper, chalcantite, has five moles of water for each mole of ionic solid and is written as $CuSO_4 \cdot 5H_2O$. Its chemical name is copper (II) sulfate pentahydrate.

Note that the term "hydrate" is imprecise as it does not tell how the water is bonded. In inorganic compounds, the water can be directly bonded to the metal center or crystallized within the metal complex. However, the formula does give the mole ratio between the ionic solid and the water molecules. Greek prefixes are used to denote the amount of water as mono-, di-, tri-, terta-, penta-, etc. In most instances, water in hydrates is present in specific integer amounts. The following salts will be analyzed:

Compound	Mineral Name
$CaSO_4 \cdot 2H_2O$	Gypsum
$MgSO_4 \cdot 7H_2O$	Epsomite
$FeSO_4 \cdot 7H_2O$	Melanterite
$(NH_4)_2SO_4 \cdot 5H_2O$	Mascagnite

[1]http://www.psrd.hawaii.edu/July03/MartianSea.html

[2]http://www.nasa.gov/mission_pages/MRO/news/mro-20080716.html

[3]http://www.nasa.gov/mission_pages/MRO/multimedia/pia09094.html

[4]http://www.nasa.gov/mission_pages/MRO/news/mro-2008108.html

Prelab Questions:

1) An unknown hydrate was evaluated for water content by gentle heating and then drying to constant weight. The following data was obtained. Calculate the percent water in the sample.

$Mass_{crucible + lid}$ (g)	10.427
$Mass_{crucible + lid + sample}$ (g)	12.170
$Mass_{crucible + lid + sample}$ (g) after drying to constant weight	11.459

Procedure:

1) Obtain a crucible and a lid. Wash and dry them. Do not worry about stains in the porcelain.
2) Adjust and light a Bunsen burner.
3) Set up a clay triangle, iron ring, and ring stand so that a Bunsen burner fit under them.
4) Heat the crucible until it is red-hot for at least 15 minutes to remove any water and/or impurities.
5) Remove the crucible carefully with crucible tongs and place on wire gauze to cool. **NOTE:** Do NOT touch the crucible once you have heated it. *Always use tongs.* This is not only to prevent any burns on your skin, but also to prevent any contamination due to oil/grease from your skin.
6) Obtain one unknown sample (approximately 0.5 g) and record the unknown code.
7) Carefully, weigh the crucible and lid using tongs to transfer to and from the balance pan.
8) Transfer 0.4xx-0.5xx g of the unknown solid to the crucible/lid, and reweigh. Do NOT forget the lid. Record the mass to 0.001 g (1 mg).
9) Place the crucible/lid containing the sample on the clay triangle, and tilt the lid slightly so that the gaseous products can escape.
10) Heat the sample slowly at first, so that the sample will not spatter. After a few minutes, apply high heat for 15 minutes.

11) Remove the flame and allow the crucible to cool. Once the crucible and lid is at room temperature, weigh it to the nearest 0.001 g.
12) Repeat steps 9-11 once more.
13) Discard the anhydrous metal compound into the trash and waste the crucible and lid.

Data/Results:

Unknown # ________________

Before Heating		After Heating	
$Mass_{crucible + lid}$ (g)		$Mass_{crucible, lid, and sample}$ (g) after 1st heating	
$Mass_{crucible + lid + sample}$ (g)		$Mass_{crucible, lid, and sample}$ (g) after 2nd heating	
$Mass_{sample, before heating}$ (g)		$Mass_{anhydrous sample}$ (g)	

Postlab Questions:

1) Calculate the percent water in each of the possible unknowns: $CaSO_4 \cdot 2H_2O$, $MgSO_4 \cdot 7H_2O$, $FeSO_4 \cdot 7H_2O$, and $(NH_4)_2SO_4 \cdot 5H_2O$.
2) Calculate the percent water in your unknown sample and determine which mineral is your unknown.
3) Epsomite, $MgSO_4 \cdot 7H_2O$, has been found on Mars. The minimum amount of water it takes to sustain a human's needs is 1.0 kg/day.
   (a) How much epsomite would you have to dehydrate to sustain four astronauts for one week?
   (b) Based on your calculations, is it effective to use minerals on Mars to sustain human life?

*Adapted from "Molecules, Moles, and Chemical Reactions"—Bottomley, L; Bottomley, L.A.; *Chem 1310: Laboratory Manual*, 2011-2012, p 13-25.